

Can renewable energy certificates buffer the impact of power outages on stock performance?

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ABSTRACT

This study uses an event study approach to investigate the impact of Renewable Energy Certificates (RECs) on company stock performance during an unexpected nationwide power outage on May 17, 2021. Our data consists of 28 companies that have installed renewable energy facilities. The results show that manufacturers holding T-RECs experienced a significant decline in stock prices on the day of the power outage, while financial and service T-REC holders were not affected. Nevertheless, over the following five days, shareholders of manufacturing companies experienced a positive daily abnormal return of 0.0046%, which is higher than the daily abnormal return of 0.0023% for financial and service companies.

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1. Introduction

Renewable energy sources such as solar, wind, and biomass are considered the best alternatives to replace fossil fuels and curb global warming (Arent et al., 2011; Holechek et al., 2022). Amidst this zero-carbon trend, enterprises face challenges in integrating renewable energy into their operations due to supply chain demands (Bonsu, 2020), carbon trading tariffs (Böhringer et al., 2021; Zhou et al., 2024), renewable portfolio standards (Joshi, 2021), and public expectations. As an export-oriented country, Taiwan established the Renewable Energy Certificate Center (T-REC Center) in 2017 to verify companies' use of green energy and facilitate the T-REC trading market. Key players in the market consist of renewable energy generators, renewable energy retailing enterprises, and renewable energy users, including giant carbon emitters, and companies that intend to achieve environmental goals and reduce climate risks (Yingxu, 2020); improve Corporate Social Responsibility (CSR) ratings and company image (Alam & Islam, 2021; Gigauri & Vasilev, 2022); and join green supply chains (Chou, Chen, & Wu, 2022; Gao et al., 2023).

As mentioned earlier, promoting renewable energy in countries with limited land areas can incur significant costs. For instance, it may come at the expense of the agriculture sector by converting farmlands for the use of green energy facilities, such as installing solar panels on agricultural land (Chang & Lin, 2023; Lee et al., 2021; Shen & Chang). Lai et al. (2019) found that the installation of solar panels increases the price of farmland by 3.40% to 37.02%. Additionally, the installation of solar panels has led to farmland fragmentation (Yu-Hsin et al., 2019).

While considerable attention has been devoted to the impact of green energy on land resources, particularly farmlands (Rahman et al., 2022), there is limited understanding of whether renewable energy can enhance a company's value and resilience. An exception is the study by Chung, Kunene, and Chang (2024), which demonstrates that T-REC purchase announcements increase a firm's market value. Moreover, their

findings reveal a notable discrepancy across industries. The market values T-REC purchases in the manufacturing industry but not in the financial and service industries. However, their study did not investigate whether installing renewable energy systems within companies can bolster their resilience to power shortages. Specifically, it did not explore whether T-REC holders outperform non-T-REC holders in the stock market during unexpected power outages. To address this question, this study utilizes an event study method to assess whether T-REC holders demonstrate resilience to power outage shocks. Additionally, we examine the heterogeneous effects across industries.

Taiwan has the fourth-lowest industrial electricity price worldwide (Enerdata, 2022). However, the cost of renewable energy is nearly three times that of industrial electricity, making Taiwan Renewable Energy Certificates (T-RECs) relatively costly for companies to purchase. This higher price reduces the incentive for companies to invest in renewable energy, which could impact their competitiveness in global value chains. Taiwan's manufacturing industry, which includes sectors like semiconductors, microelectronics, optoelectronics, and precision machinery, is highly valued but also energy-intensive, facing risks from global carbon regulations (Chuang et al., 2019; Finnerty et al., 2018; Napp et al., 2014). This context makes Taiwan a unique case to study not only the value T-RECs provide to companies but also the variation in T-REC purchases across different industries. To explore this, we collect data from 28 companies—including manufacturers, financial institutions, and service providers—that hold T-RECs. We then analyze their abnormal returns and trading volumes during Taiwan's unexpected nationwide power outage on May 17, 2021.

2. Research Method

Power Outage Event in Taiwan

Since Taiwan declared its commitment to transition toward a 「nuclear-free homeland」 in 2011, right after the earthquake occurring in Japan (Fathima, 2023), Taiwan has ceased using nuclear energy and replaced it with renewable energy afterwards. Power shortages have been a major concern for industrial sectors, affecting business operations. An unexpected power outage occurred at noon time on May 17, 2021, and lasted for 8 hours, which caused huge business losses in the private sector.

An event study approach requires defining the event window and the estimation window. The former refers to the time period during which stock price and volume are affected by the event, while the latter is the period without event-specific disturbances (Guo, Kuai, and Liu, 2020). According to Blumsack and Ositelu (2015), a one-week span is suitable for capturing short-term responses. In this study, as shown in Figure 1, we use an event window spanning 5 days after the power outage on May 17. The estimation window is set to [-55, -11], a period during which no other specific events occurred in Taiwan.

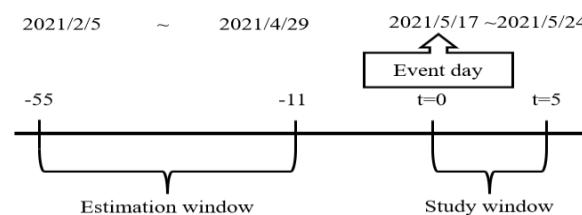


Figure 1. Event window

Data

To examine the market value of T-RECs for companies and their value across industries during periods of power shortage, we collected all T-REC transactions from the T-REC Center between June 2017 and April 2021. We focus on publicly listed companies with renewable energy facilities installed on their rooftops or nearby locations. This selection resulted in a sample of 28 listed companies. Using Taiwan's Standard Industrial Classification (SIC) code, we categorize these companies into 15 in the manufacturing industry and 13 in the financial and services industry. Since these companies are registered with the T-REC Center, we are able to track their names, transaction dates, transaction quantities, and energy types.

Stock Exchange Market

Figure 2 shows the stock performance from February 5, 2021, to May 24, 2021. May 17 is the event day, so the event window is from May 17 to May 24 (the market was closed on May 22 and 23 due to the weekend), and the estimation window is from February 5 to April 29. As shown in the figure, the estimation window days exhibit an upward trend and did not experience a significant dip in stock price.

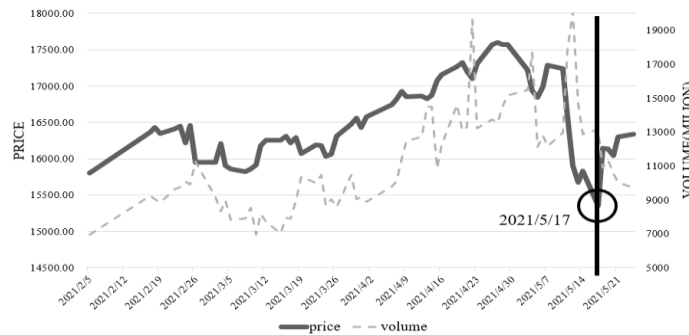


Figure 2. Stock price and volume

Event Study

The event study approach has been widely used to estimate market response to unexpected shocks such as natural disasters, financial crises, and good or bad news affecting companies’ stock performance. For example, He et al. (2021) employed an event study approach to explore the impact of the COVID-19 pandemic on stock market performance across industries. Their findings suggest that the manufacturing, education, and healthcare industries outperformed others during the COVID-19 outbreak. Similarly, Dimpfl (2011) used an event study to examine the impact of U.S. news on the German stock market and found significant results.

The steps of the event study approach are introduced as follows: Equation (1) is used to estimate the coefficient β of an individual company’s performance relative to market performance:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it} \dots\dots\dots(1)$$

Where i is company; t indicates time; R_{it} represents the return of i company on t day; R_{mt} indicates the return of m market on t day, α_i and β_i are the parameters that should be estimated. ε_{it} is an error term, following a normal distribution.

From Eq (1), we obtain the expected abnormal return $E(R_{it})$ as Eq (2)

$$E(R_{it}) = \alpha_i + \beta_i R_{mt} \dots\dots\dots(2)$$

The abnormal return is calculated as the difference between the real return and the expected return, which is expressed as Eq. (3).

$$AR_{it} = R_{it} - E(R_{it}) \dots\dots\dots(3)$$

To study the abnormal returns of sample companies around the power outage, the Average Abnormal Return (AAR) is defined as follows:

$$AAR_t = \frac{1}{N} \sum AR_{it} \dots\dots\dots(4)$$

We aggregate the cumulative abnormal returns across N sample firms over the window to test the null hypothesis that the buying of REC does not affect firms’ returns. The average cumulative abnormal return (CAAR) is expressed as:

$$CAAR_t = \sum AAR_{it} \dots\dots\dots(5)$$

3. Result and Discussion

This study utilizes T-REC transaction data and employs an event study method to examine the effects of an unforeseen power outage in Taiwan on the transaction price and quantity of T-REC holders. Firstly, we present the descriptive statistics of the sample. Secondly, we present the results of AAR, AAV, CAAR, and CAAV and draw conclusions based on our findings.

Descriptive Statistics

Table 1 presents the sample statistics for a total of 28 companies that possess T-RECs. As of 2021, these companies have an average history of about 46 years. Manufacturing companies have a longer average history of 49 years, while financial and service companies have an average history of 43 years. The total sample has a combined capital of 400.49 billion NTD in 2021. On average, manufacturing companies have a capital of about 313 billion NTD, whereas financial and service companies have a higher average capital of 501 billion NTD.

During the research period, the average stock price during the event window was \$118.84 per share, lower than the average price of \$120.29 per share during the estimation window. Similarly, the transaction volume during the event window was 9,384.58 shares, lower than the 9,838.26 shares during the estimation window. These figures suggest that stock performance underperformed during the event window. However, industries tell a different story; while manufacturing had lower performance during the power outage shock period, the financial and service industries fared better during the event period.

Table 1. Descriptive statistics

	All N=28		Manufacturing N=15		Financial and service N=13	
	Mean	SD	Mean	SD	Mean	SD
Firm age(year)	46.46	19.63	49.27	22.25	43.23	16.37
Capital(Billion)	400.49	599.32	313.31	654.17	501.09	537.06
Stock price (NTD)	[0, 5] 118.84	194.19	179.95	248.31	48.34	33.43
	[-55,-11] 120.29	197.70	182.89	252.24	48.06	32.80
Stock volume	[0, 5] 9384.58	11585.17	9094.39	9957.76	9719.42	13276.68
	[-55,-11] 9838.26	13706.82	11256.22	15260.71	8202.16	11454.87

1 USD = 30.73 NTD in May 2021.

Average Abnormal Return

Table 2 displays the results of the AAR calculated using Eq. (3). The findings in the 'All' panel suggest that companies holding T-RECs experienced a significant decline of -0.036% in average abnormal return on the day of the power outage. In the subsequent three days following the event, prices continued to decline, although not statistically significantly, until a moderate rebound was observed on the fourth and fifth days. When examining the data by industry, a significant difference between the manufacturing industry and the financial and service industry is noted, particularly on the event day and the fourth and fifth days afterward.

Table 2. Average abnormal return

	All			Manufacturing			Financial and service		
	AAR(%)	Patell test		AAR(%)	Patell test		AAR(%)	Patell test	
0	-0.0360	0.0383	*	-0.0429	0.0336	***	-0.0280	0.0437	
1	0.0452	0.0252		0.0618	0.0320	***	0.0260	0.0174	**
2	-0.0033	0.0224		-0.0087	0.0236	*	0.0030	0.0210	***
3	-0.0042	0.0254		0.0006	0.0329	**	-0.0098	0.0168	***
4	0.0133	0.0189	*	0.0120	0.0227		0.0148	0.0146	***
5	0.0052	0.0195	***	0.0050	0.0214		0.0053	0.0172	***

The manufacturing industry exhibited a significant decline in AAR on the event day. In contrast, the financial and service industries did not experience a significant shock on the event day and even showed a recovery in stock prices after the event. Therefore, despite both sectors experiencing fluctuations in AAR following the power outage, the financial and service sectors tended to recover more quickly than the manufacturing sector.

Table 3 displays the average abnormal volume (AAV). Companies that installed renewable energy facilities and held T-RECs experienced shrinking transaction volumes following the outage event, with a rebound observed on the third day. Moreover, contrary to the AAR findings in Table 2, no differences between industries were observed. These figures suggest that investors in Taiwan were concerned about the power shortage in industries and pessimistic about future stock prices, which may have led them to sell off their stock shares.

Table 3. Average abnormal volume

	All			Manufacturing			Financial and service		
	AAV(%)	Patell test		AAV(%)	Patell test		AAV(%)	Patell test	
0	0.3711	0.2040	**	0.1653	0.0459		0.6085	0.3864	***
1	-0.2845	-0.1477	*	-0.1927	-0.0197		-0.3905	-0.2954	**
2	-0.2351	-0.3794	***	-0.2627	-0.3660	***	-0.2032	-0.3949	***
3	0.4878	0.3000	***	0.6459	0.2795	*	0.3054	0.3235	**
4	-0.0954	-0.1261		-0.0407	-0.0759		-0.1586	-0.1840	
5	-0.0832	-0.1535	**	0.0090	-0.1197		-0.1896	-0.1926	

Cumulative Average Abnormal Return (CAAR)

CAAR, which accumulates AAR, illustrates the abnormal return caused by the event if the shares are not sold. Table 4 indicates that the market reacts positively toward manufacturing companies holding T-RECs, recording a CAAR of 0.0189% during the [0,1] day period, which increases to 0.0279% over the [0,5] day period. This suggests a daily abnormal return of 0.0046% after the shock in the manufacturing industry. In contrast, T-REC holders in the financial and service industries experienced negative CAARs for the [0,1] and [0,3] windows. However, if investors in this sector did not sell their shares, they observed a CAAR of 0.0112% during the [0,5] period, indicating a daily abnormal return of 0.0023%, which is lower than the return in the manufacturing industry. These figures indicate that despite experiencing fluctuations in returns, investors holding T-RECs, particularly those in the manufacturing sector, had abnormal returns compared to non-T-REC holders.

Table 4. Cumulative average abnormal return

	All			Manufacturing			Financial and service		
	CAAR(%)	Patell test		CAAR(%)	Patell test		CAAR(%)	Patell test	
[0,1]	0.0092	0.0635	**	0.0189	0.0656	***	-0.0020	0.0611	**
[0,2]	0.0059	0.0859		0.0101	0.0893	***	0.0009	0.0821	***
[0,3]	0.0017	0.1114		0.0108	0.1222	***	-0.0089	0.0989	***
[0,4]	0.0150	0.1303		0.0228	0.1448	***	0.0059	0.1135	***
[0,5]	0.0201	0.1497		0.0279	0.1662	***	0.0112	0.1307	***

Table 5 presents the CAAV, which can predict the future market's perspective toward T-REC holders' investment in renewable energy. In the table, none of the figures are significant, although some CAAVs are positive and others are negative. This implies that overall, the market remained alert about the power outage but might have been reassured by the T-REC holders' renewable energy supply systems, adopting a wait-and-see approach.

Table 5. Cumulative average abnormal volume

	All		Manufacturing		Financial and service	
	CAAV(%)	Patell test	CAAV(%)	Patell test	CAAV(%)	Patell test
[0,1]	0.0866	0.0563	-0.0274	0.0262	0.2180	0.0910
[0,2]	-0.1485	-0.3231	-0.2901	-0.3398	0.0148	-0.3039
[0,3]	0.3393	-0.0232	0.3559	-0.0603	0.3202	0.0196
[0,4]	0.2439	-0.1493	0.3151	-0.1362	0.1616	-0.1644
[0,5]	0.1607	-0.3028	0.3241	-0.2559	-0.0279	-0.3569

4. Conclusion

This study examines the stock performance of T-REC holders during the unexpected nationwide power outage on May 17, 2021, in Taiwan. Using an event study approach, the results show that all 28 T-REC holders experienced a decline in stock performance, particularly on the day of the outage. However, 15 manufacturing companies showed a noticeable recovery in the days following the event. These findings suggest that T-RECs can help buffer companies from external shocks related to power disruptions, with manufacturers recovering more quickly than service companies.

A potential reason for this could be that the financial and service industries are relatively low energy consumers and are generally exempt from carbon regulations. Consequently, the market may view renewable energy purchases as a costly investment for non-manufacturing industries, potentially leading to a lower market valuation of T-RECs for financial and service companies. In contrast, for the energy-intensive manufacturing sector, the market views rooftop renewable energy installations as a valuable investment for business operations, enhancing resilience to climate-related risks.

Finally, as T-REC usage can enhance companies' competitiveness within global value chains and markets, policymakers should support renewable energy security for companies by installing solar panels on rooftops and diversifying renewable energy sources, such as biomass, geothermal, and hydro energy.

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